

1 CLAIMS

2 I claim:

3 1. An apparatus for filtration of water from hydrocarbons comprised of

4 a) a fresh-feed inlet,

5 b) a first dead end filter, having a filter medium that is hydrophobic,

6 c) a second cross-flow filter, having a membrane that is hydrophobic,

7 d) a common housing to contain both the first and second filters,

8 e) a system for the recirculation of the retentate,

9 f) a chamber for water settling, and

10 g) an outlet for clean fuel permeate.

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12 2. The filtration apparatus as set forth in claim 1, further characterized by a ratio  
13 of cross-flow to fresh-feed in the range of 1:1 to 1:30.

14

15 3. The filtration apparatus as set forth in claim 1, wherein the pressure differential  
16 between the feed pressure and the permeate pressure is less than or equal to  
17 50psi.

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19 4. The filtration apparatus as set forth in claim 1, wherein the operating  
20 temperature is maintained below or equal to 130 degrees Fahrenheit.

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1 5. The filtration apparatus as set forth in claim 1, wherein said first dead end filter  
2 is made from a material selected from the group consisting of nylon, polyester,  
3 polyvinylidene difluoride and polypropylene.

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5 6. The filtration apparatus as set forth in claim 1, wherein said first dead end filter  
6 has a pore size in the range of 0.5  $\mu\text{m}$  to 100  $\mu\text{m}$ .

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8 7. The filtration apparatus as set forth in claim 1, in which said second cross-flow  
9 filter is of a type selected from the group consisting of spiral wound module  
10 cartridges, tubular cartridges and hollow fiber cartridges.

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12 8. The filtration apparatus as set forth in claim 1, in which said second  
13 hydrophobic cross-flow filter is made from polytetrafluoroethylene membrane.

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15 9. The filtration apparatus as set forth in claim 8, further characterized by the  
16 polytetrafluoroethylene membrane having a sub micron pore size.

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18 10. The filtration apparatus as set forth in claim 8, wherein the  
19 polytetrafluoroethylene membrane is of 0.1  $\mu\text{m}$  pore size.

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21 11. An apparatus for filtration of water from hydrocarbons comprised of  
22 a) a top chamber;  
23 b) a feed chamber;

- c) a chamber for water settling;
- d) a permeate chamber;
- e) a fresh-feed inlet, communicating with said feed chamber;
- f) a first dead end filter, having a filter medium that is hydrophobic, communicating on its inlet side with said feed chamber and on its outlet side with said top chamber;
- g) a perforated tube sleeve guide containing said first dead end filter;
- h) a second cross-flow filter, having a membrane that is hydrophobic, communicating on its inlet end with said top chamber and on its outlet end with a said chamber for water settling, which filter is further characterized by having a center tube for collection of permeate, communicating with said permeate chamber;
- i) a non-perforated tube sleeve guide, containing said second cross-flow filter;
- j) a common housing to contain both said first and second filters, including an elongate housing wall having opposed first and second open ends, an elongate cylindrical interior surface defining a housing cavity, and a series of plates extending across said open ends of said housing wall, defining said chambers;
- k) a system for the recirculation of the retentate, including a port for outlet of the concentrate in fluid communication with said chamber for water settling, a circulation pump and a feed inlet having fluid communication with the feed chamber in the housing; and

- 1           i) an outlet for clean fuel permeate in fluid communication with said
- 2           permeate chamber.

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4 12. The apparatus for filtration of claim 11, further characterized by a ratio of  
5 cross-flow to fresh-feed in the range of 1:1 to 1:30.

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7 13. The apparatus for filtration of claim 11, wherein the pressure differential  
8 between the feed pressure and the permeate pressure is less than or equal to  
9 50psi.

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11 14. The apparatus for filtration of claim 11, wherein the operating temperature is  
12 maintained below or equal to 130 degrees Fahrenheit.

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14 15. The apparatus for filtration of claim 11, wherein said first dead end filter has a  
15 pore size in the range of 0.5  $\mu\text{m}$  to 100  $\mu\text{m}$ .

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17 16. The apparatus for filtration of claim 11, in which said second hydrophobic  
18 cross-flow filter is made from polytetrafluoroethylene membrane.

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20 17. The apparatus for filtration of claim 16, wherein the polytetrafluoroethylene  
21 membrane is of 0.1  $\mu\text{m}$  pore size.

22

23 18. An apparatus for filtration of water from hydrocarbons comprised of

1                   a) a fresh-feed inlet,

2                   b) a plurality of first dead end filters, having filter media that are

3                    hydrophobic,

4                   c) a plurality of second cross-flow filters, having membranes that are

5                    hydrophobic,

6                   d) a common housing to contain said first and second filters,

7                   e) a system for the recirculation of the retentate,

8                   f) a chamber for water settling, and

9                   g) an outlet for clean fuel permeate.

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11           19. An apparatus for filtration of water from hydrocarbons comprised of

12                   a) a fresh feed inlet,

13                   b) a first dead end filter, having a filter medium that is hydrophobic, in

14                   series with a second cross-flow filter, having a membrane that is

15                   hydrophobic, each filter being disposed within a separate housing,

16                   c) a system for the recirculation of the retentate,

17                   d) a chamber for water settling, and

18                   e) an outlet for clean fuel permeate.

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20           20. A method for removal of water from hydrocarbon liquid fuels containing

21                   surfactants, comprising the steps of

22                   a) passing a water emulsion-containing fuel through a first hydrophobic

23                   filter,

